RESTRICTED

DS Regs Cand

REPORT No 2/70

COPY No 14

ROYAL NAVAL PHYSIOLOGICAL LABORATORY ALVERSTOKE

PROVISIONAL OXY-HELIUM DIVING TABLES (200 feet - 500 feet) 1970

PART I - SHORT DURATION DIVES (LESS THAN 15 MINUTES BOTTOM TIME)

PART II - 1 HOUR AND 4 HOUR DURATION DIVES

BY

H.V. HEMPLEMAN AND C. TROTTER

This document is the property of H.M. Government. The contents may be disclosed only within defence departments, except as otherwise authorised by the Ministry of Defence

DEPARTMENT OF NAVAL PHYSICAL RESEARCH MINISTRY OF DEFENCE

RESTRICTED

PROVISIONAL OXY-HELIUM DIVING TABLES

(200 feet - 500 feet) 1970

PART I - SHORT DURATION DIVES (LESS THAN 15 MINUTES BOTTOM TIME)

PART II - 1 HOUR AND 4 HOUR DURATION DIVES

BY

H.V. HEMPLEMAN AND C. TROTTER

PADI INSTRUCTOR 33913 Albrecht Salm

PADI Albrecht Salm Master Scuba Diver Trainer PADI MSDT # 33913

10/2026

TABLE OF CONTENTS

	PAGE
Introduction	1
Experimental data and theoretical background	1
Short and long deep dives present position	3
Release of Tables	4
PART I	
SHORT DURATION DIVES (LESS THAN 15 MINUTES BOTTOM TIME	
Some practical considerations	4
Use of the Tables (Table I)	6
Table I - Decompression Tables, short duration dives	7
Emergency procedures	18
Table 2 - Emergency air breathing Table	19
PART II	
1 HOUR AND 4 HOUR DURATION DIVES	
Practical considerations	20
Use of the Tables (3 and 4)	22
Table 3 - Decompression Tables, 1 hour bottom time	23
Table 4 - Decompression Tables, 4 hours bottom time	30
Table 5 - Oxygen and carbon dioxide tolerances	37
Appendix I - Treatment of decompression sickness from Oxy-helium diving	40
Table 6 - Oxy-helium recompression therapy	42

INTRODUCTION

1. When a diver breathes air at a pressure of 3 atmospheres, that is corresponding to 66 feet under the sea, then, as one-fifth of this total pressure is oxygen he is breathing an oxygen pressure of three-fifths of an atmosphere, and such a pressure of oxygen represents the maximum permissible to avoid the ill-effects of prolonged oxygen breathing. Thus, although air covers a great range of pressure-time possibilities, any attempt to stay at pressures greater than 66 feet for prolonged periods will necessitat a change to a lower oxygen content. Deeper than 66 ft will hasten the onset of oxygen toxicity. For example at 10 atmospheres of air pressure, the oxygen partial pressure is 2 atmospheres and this pressure cannot be safely tolerated longer than 30 minutes.

2. Additionally, although nitrogen does not react chemically with the body it does nevertheless interfere with the functioning of the central nervous system and produces a state of stupefaction and unreliability at pressure which is called "nitrogen narcosis". This narcosis is just detectable in most normal men at 100 feet depth on air and is obvious on all men at a depth of 300 feet. At 200 feet depth it is generally agreed that the nitrogen pressure of air is too great for regular reliable work except by very practised divers. Thus, for effective diving deeper than 200 feet a gas other than nitrogen, associated with an appropriate oxygen pressure, is necessary. There are only three possibilities: neon, hydrogen and helium, or of course, various mixtures of these three. Neon has been tested, and the theoretical expectations that it would be better than nitrogen are justified. However, neon is prohibitively expensive and this has led to it being rejected for further work. Hydrogen, first breathed at pressure in 1941 in this country and later used by the Swedish Navy in certain experimental sea dives, represents a distinct possibility for deep diving. Unfortunately, it is explosive when mixed with most concentrations of oxygen and is therefore an extremely difficult gas to use from a safety view point and very little experimental work has been pursued with this gas. All the deep-diving experimentation forming the basis of these tables has been performed using oxygen/helium mixtures only. No ternary breathing mixtures of helium with the above mentioned inert gases, or air, have been used as this would further complicate an already complex situation and make experimental interpretation even more difficult.

EXPERIMENTAL DATA AND THEORETICAL BACKGROUND

3. It was first established that prolonged breathing of oxy-helium at relatively low pressures, eg. 40 feet, followed by rapid decompression to atmospheric pressure, was a considerably safer procedure than corresponding exposures of air, but conversely no-stop dives for short durations (eg. 15 minutes) on the helium breathing mixture, could not be safely performed at pressures well established as safe when breathing air. Thus, as might be expected, the shape of the no-stop curve for helium is quite markedly different from that of air. Helium is much less soluble in all body tissues than nitrogen, and hence the quantity of gas available for bubble formation after prolonged exposure at pressure is considerably less than that of nitrogen. This accounts for the better performance on helium following a prolonged exposure. On the other hand, helium is a very rapidly diffusing gas and for short periods will saturate body tissues correspondingly more rapidly than nitrogen, which partly contributes to the lower permitted no-stop limits for short duration dives. Due to this greater diffusibility

both bubble formation and regression are much faster processes than with nitrogen. It was early established that the Haldane concept that rapid decompression from 8 atmospheres to 4 atmospheres was just as safe as rapid decompression from 2 atmospheres to 1 atmosphere (ie. constant ratio) whilst representing a good working hypothesis was not sufficiently accurate to permit the calculation of safe dives. Defining the relationship between the safe decompression ratio and pressure requires large numbers of men working at a variety of pressure-time combinations. Such basic evidence has not yet been properly established due to the difficulty of finding the required large number of volunteers, but guidelines have been obtained and are incorporated in the schedules given in this report.

4. The rate of uptake and elimination of the effects of breathing helium at pressure are also problems awaiting proper quantitative answers. Nevertheless, sufficient evidence has accumulated to permit reasonable estimates to be made.

5. From an appraisal of past diving and following our own experimentation, it became clear that helium saturates the body quite rapidly at first but with a 'tail' to the saturation curve which asymptotes in the order of six hours. A small but significant difference was found between diving for 4 hours at 300 feet and diving for 8 hours. Such a difference could not be established at much lower pressure, but this may be due to lack of sufficient statistical validation or to adaptive changes of the body at high pressures influencing the decompression. Following stage decompression it became clear that whereas the uptake of helium gas seemed to be complete in the order of 6 to 8 hours in most individuals, the elimination of the helium effects took far longer, and the establishment of the kinetics of elimination of helium from tissues was the major difficulty. From the no-stop curve the shape of the uptake of helium was assumed to follow a similar course to that of nitrogen, but with altered time scale. An estimate was made of the rate of elimination of helium using exactly the same shaped curve, but with an extended time scale. Using these two curves for uptake and elimination of helium and following the establishment of a safe decompression ratio, it was possible to calculate decompression tables. Such tables were then put to the test by exposing men, two at a time, in dry chambers. Only when 10 dives on 10 separate individuals had been accomplished without signs or symptoms of decompression sickness were such procedures further tested at sea. Failure to complete 10 successful dry dives caused a revision in the system of calculation. Such revisions of calculation generally involved reducing the permitted ratio or extending the time scale of the elimination of helium curve or a combination of these two variables. By such means a number of successful dive procedures was established.

6. A mathematical analysis of the successful pressure-time courses was undertaken, and the somewhat surprising fact was established that despite a wide disparity in times at depth and pressures used, a simple plot of pressure versus square root of decompression time yielded a linear curve. This simple observation was then used for the calculation of several subsequent successful dive profiles, eg. 1 hour at 450 feet and 600 feet, 20 minutes at 800 feet. The method was clearly promising and only minor modifications were needed for establishing the slope and intercepts of the linear plot.

7. It was found from both the theoretical prediction and subsequent testing, that a 15 minute dive to 500 feet required a decompression procedure lasting approximately 5½ hours. Using the available breathing apparatus it

was also established that this decompression time represented the limits of endurance for breathing continuously from such apparatus. From experiments on submarine escape it was known that men could breathe pressures of air to depths of the order of 500 feet for periods not exceeding one minute without noticeable behavioural changes. Consequently, it was decided that short duration dives with the diver breathing oxy-helium from a breathing apparatus, but surrounded by an atmosphere of air could be performed safely at depths down to a maximum of 500 feet. It was considered that in the event of an oxy-helium supply failure, chamber air could be breathed during the initial fast decompression phase to the much safer level of the first stop (290 feet). Once the decision has been taken that the diver will remain on breathing apparatus and be surrounded by air, the diving technique involved is considerably simplified in many respects. Firstly, fixed compositions can be used in the cylinder banks supplying the diver with breathing breathing gas, and such a procedure avoids the necessity for accurate gas mixing on board the diving vessel. Secondly, being surrounded with air ensures good thermal insulation when compared with being surrounded by oxy-helium, and thus diver heating is much less of a problem. Thirdly, there is no need for complex life support systems to ensure correct oxygen and carbon dioxide levels. Fourthly, there is a very considerable saving in the cost of pressurising a chamber with air rather than with oxy-helium.

8. The diving tables are therefore presented in two parts. Part I is for short duration dives where breathing apparatus is tolerable. Part II is for longer dives of 1 hour and 4 hours where the breathing and diving techniques are markedly different.

SHORT AND LONG DEEP DIVES PRESENT POSITION

9. There is a rather sharp divergence of opinion within the diving profession about the effectiveness of short bottom time diving. Some state that all underwater work should be planned from an engineering point of view in a manner requiring minimum assistance from the diver. Only rarely, according to them, is more than a 15 minute dive necessary and the diver can be replaced at frequent intervals. The need for longer bottom times according to this view is evidence of poor organisation. The other opinion asserts that the ratio of bottom time to decompression time for 15 minute dives is so low with present deep diving technique that such diving is uneconomic from both a time and money standpoint. Consequently, they demand saturation diving techniques by means of which men spend many hours or even days at pressure. This means that work on the undersea job can be carried out on a continuous unhurried schedule.

10. The schedules given in the Report must be regarded as provisional in the sense that they have not been fully tested over the range of pressures, times, water conditions and numbers of different men to establish their complete reliability. Many experimental sea dives to establish their validity have been undertaken in the Royal Navy but these have been chiefly restricted to short periods due to the limitations of the sea-borne equipment. The Tables are not yet in operational use, but it is reasonably certain that they will be less liable to provoke attacks of decompression sickness than any previously used. For example, 100 sea dives to 300 feet for 15 minutes have resulted in one bend requiring recompression, and over 100 chamber work dives have yielded two bends requiring recompression, using less adequate decompression than given in the enclosed Tables. It is to be expected therefore that for short duration dives 2% bends will not be exceeded by correct and continuous use of the schedules.

11. For the long duration dives in Part II it is not possible to advance such a wealth of information regarding the performance of the schedules. It can be said that for dry chamber diving these schedules would be quite safe to use. When used at sea results were disappointing with the original calculations on 1 hour at 450 feet and 1 hour at 600 feet. However, it is apparent that the troubles brought on when sea testing the schedules were attributable to lack of suitable environmental control not met in the laboratory testing, eg. temperature, depth keeping, but even so, due cognizance has been taken of these results and the schedules altered in such a manner as is known from past experience to lead to greater security.

RELEASE OF TABLES

12. In response to requests it has been decided to make these Tables available, without liability, to industrial concerns employing experienced divers, who wish to use them. Arrangements are being made for users of these tables to keep accurate records of all dives. Co-operation in compiling the records will assist in the more rapid validation of the diving tables.

PART I

SHORT DURATION DIVES (LESS THAN 15 MINUTE BOTTOM TIME)

SOME PRACTICAL CONSIDERATIONS

13. The equipment must be such that the diver can be supported in a reasonable state of comfort at all pressures up to the maximum diving pressure for an indefinite period. This basic safety requirement can be met in a number of different ways, eg. by the use of a submersible chamber with lock-on facilities at the surface, a submarine with a diver lock-out system or a large diving bell with adequate surface support.

14. Deep diving in the Royal Navy is at present based on the former, ie. a submersible compression chamber with transfer under pressure facilities at the surface. The diver is lowered to the working depth in the submersible chamber with the bottom door open and ingress of water is prevented by adjusting the chamber air pressure. Following completion of his underwater task the submersible chamber is brought to the surface after closing the bottom door at pressure, and is locked on to a larger deck-mounted pressure chamber into which the diver transfers when the pressures of these two chambers have been equalised.

15. For short duration dives it is standard practice in the Royal Navy to employ gas mixtures of fixed composition, a built-in breathing system in the pressure chamber, and to use open circuit breathing apparatus fitted with servo-assisted demand valves. If semi-closed or closed circuit breathing apparatus is used, great care must be exercised to maintain the correct partial pressures of oxygen.

16. It should be noted that when the diver is breathing one gas mixture whilst surrounded in the pressure chamber by a gas mixture of a different composition, care must be exercised to ensure that no leaks occur around face seals or mouthpieces; such leaks can be particularly serious with ill-fitting ori-nasal masks.

17. To estimate approximately the quantities of gas involved with open circuit breathing apparatus allow 1 cubic foot of gas per minute per atmosphere. For example, at 300 feet depth (10 atmospheres) one man would use 10 cubic feet of gas per minute, as measured at 1 atmosphere (surface pressure).

18. For diving to 250 feet, only air and one gas mixture 20% oxygen and 80% helium as well as pure oxygen for the ascent from 50 feet to the surface are involved throughout the total time of the dive. For dives from 300 feet to 500 feet, in addition to air, two gas mixtures are required; 10% oxygen, 90% helium and 20% oxygen, 80% helium, as well as pure oxygen for the ascent from 50 feet to the surface.

19. Oxygen tolerances allowable in the oxy-helium mixtures are $\pm$ 1% in the 20% range and $\pm$ 0.5% in the 10% range.

20. In addition to the above gas mixtures a supply of pure helium is also required and this should have a purity equal to that of Grade 'A' (US Bureau of Mines) ie. 99.995%.

21. All oxygen used should be a breathing grade with a purity of not less than 99.5%, and should comply with the standards given in the schedule of Tests for Oxygen in British Pharmacopoeia.

22. Good communications present a problem in deep diving. Verbal communication when breathing oxy-helium is impossible unless a suitable helium voice 'unscrambler' is used. Closed circuit television with visual signalling is very helpful if no 'unscrambler' is available.

23. All new starters to deep helium diving, and experienced divers who have had a lay-off period, must be gradually introduced, or re-introduced, to these deep dives. It is suggested that shallow (90 feet), medium (180 feet) and deep (250 feet) dives be attempted before making regular deep dives on helium. Apart from familiarising the diver with the gear and procedures, it also adapts him bodily and mentally to the human problems of deep diving.

PART I

SHORT DURATION DIVES (LESS THAN 15 MINUTE BOTTOM TIME)

USE OF THE TABLES(1)

24. These Tables should only be used in association with a good general code of diving practice.

25. Two divers enter the compression chamber and compressed air is added until 100 feet depth equivalent is reached in 1 minute. At this point the divers change to breathing the oxy-helium mixture supplied via the built-in breathing system. This transfer only takes a matter of seconds. On completion of the changeover pressurisation re-commences at 100 feet per minute until maximum pressure is reached. One diver acts as attendant and remains in the chamber whilst the other works outside in the sea. Both divers should be inside the chamber 30 seconds before the decompression commences.

26. From leaving surface to leaving bottom must not exceed 15 minutes.

27. Ensure that the diver is supplied with the correct composition of gases required throughout the dive.

28. Change breathing mixtures at the commencement of the appropriate stop.

29. Descent to depth must not be faster than 100 feet per minute.

30. Ascent not faster than 50 feet per minute to the first stop.

31. Do not proceed faster than 20 ft per min between stops. If time is lost on ascent do not shorten the stop times.

32. Ascent times and stop times are shown separately.

33. Time of decompression stops in the Tables is in minutes.

TABLE I

Breathing Gases

200 FEET FOR 15 MINUTES ~~BUT~~ 20% OXYGEN 80% HELIUM CHANGING TO OXYGEN ON ASCENT TO 50 FEET

DEPTH IN FEET	TIME (MINS) ARRIVE	TIME (MINS) LEAVE	STOP TIME (MINS)	RATE of ASCENT (FT/MIN)	GAS	NOTES
0'	-	0			AIR	COMPRESSION 1. Descent rate NOT TO EXCEED 100 ft/min. 2. On reaching 100 ft divers will change to 20/80 OXY-HELIUM.
100'*	1	-			*20/80	
200'	2	15			"	
60'	18	21	3	50	20/80	DECOMPRESSION 3. Ascent rate to be approximately 50 ft/min to the 1st STOP (60') and thereafter 20 ft/min between subsequent STOPS. 4. OXYGEN breathing commences on arrival at 50 FEET STOP and for the remainder of the decompression time. 5. ASCENT times are NOT INCLUDED in STOPS but are additive. 6. Time on 20/80 - 20½ mins. Time on OXYGEN - 34½ mins.
50'*	-	27½	6	20	*OXYGEN	
40'	-	30	2	"	"	
30'	-	34½	4	"	"	
20'	-	41	6	"	"	
10'	-	55½	14	"	"	
0'	56			"	"	

TABLE I

250 FEET FOR 15 MINUTES ON 20% OXYGEN 80% HELIUM CHANGING TO OXYGEN ON ASCENT TO 50 FEET

DEPTH IN FEET	TIME (MINS) ARRIVE	TIME (MINS) LEAVE	STOP TIME (MINS)	RATE OF ASCENT (FT/MIN)	GAS	NOTES
0'	-	0			AIR	COMPRESSION 1. Descent rate NOT TO EXCEED 100 ft/min.
100'*	1	-			*20/80	
250'	2½	15			"	2. On reaching 100 ft divers will change to 20/80 OXY-HELIUM.
90'	18½	21½	3	50	"	DECOMPRESSION 3. Ascent rate to be approximately 50 ft/min to the 1st STOP (90') and thereafter 20 ft/min between subsequent STOPS.
70'	-	27½	5	20	"	
60'	-	33	5	"	"	
50'*	-	39½	6	"	*OXYGEN	4. OXYGEN breathing commences on arrival at 50 FEET STOP and for the remainder of the decompression time.
40'	-	42	2	"	"	
30'	-	46½	4	"	"	5. ASCENT times are NOT INCLUDED in STOPS but are additive.
20'	-	55	8	"	"	
10'	-	71½	16	"	"	6. Time on 20/80 OXY-HELIUM - 32½ mins Time on OXYGEN - 38½ mins
0'	72				"	

TABLE I

300 FEET FOR 15 MINUTES ON 10% OXYGEN 90% HELIUM CHANGING TO 20% OXYGEN 80% HELIUM ON ASCENT TO 120 FEET AND TO OXYGEN AT 50 FEET.

DEPTH IN FEET	TIME (MINS)		STOP TIME (MINS)	RATE OF ASCENT (FT/MIN)	GAS	NOTES
	ARRIVE	LEAVE				
0'	-	0			AIR	COMPRESSION 1. Descent rate NOT TO EXCEED 100 feet/min 2. On reaching 100 ft divers will change to 10/90 OXY-HELIUM.
100'*	1	-			*10/90	
300'	3	15			"	
120'*	19	22	3	50	*20/80	DECOMPRESSION 3. Ascent rate to be approximately 50 ft/min to 1st STOP (120') and thereafter 20 ft/min between subsequent STOPS. 4. On ascent to 120 ft divers will change to 20/80 OXY-HELIUM and remain on this mixture until ascent to 50 ft. 5. OXYGEN breathing commences on arrival at 50 ft STOPand for the remainder of the decompression time. 6. ASCENT times are NOT INCLUDED in STOPS but are additive. 7. Time on 10/90 - 18 mins. Time on 20/80 - 36½ mins. Time on OXYGEN - 52½ mins.
100'	-	28	5	20	"	
90'	-	33½	5	"	"	
80'	-	39	5	"	"	
70'	-	46½	7	"	"	
60'	-	55	8	"	"	
50'	-	61½	6	"	*OXYGEN	
40'	-	66	4	"	"	
30'	-	74½	8	"	"	
20'	-	87	12	"	"	
10'	-	107½	20	"	"	
0'	108				"	

TABLE I

350 FEET FOR 15 MINUTES ON 10% OXYGEN 90% HELIUM, CHANGING TO 20% OXYGEN 80% HELIUM ON ASCENT TO 160 FEET AND TO OXYGEN AT 50 FEET.

DEPTH IN FEET	TIME (MINS)		STOP TIME (MINS)	RATE OF ASCENT (FT/MIN)	GAS	NOTES
	ARRIVE	LEAVE				
0'	-	0			AIR	COMPRESSION 1. Descent rate NOT TO EXCEED 100 feet/min. 2. On reaching 100 ft divers will change to 10/90 OXY-HELIUM.
100'*	1	-			*10/90	
350'	3½	15			"	
160'*	19	22	3	50	*20/80	DECOMPRESSION 3. Ascent rate to be approximately 50 ft/min to 1st STOP (160') and thereafter 20 ft/min between subsequent STOPS. 4. On ascent to 160 ft divers will change to 20/80 OXY-HELIUM and remain on this mixture until ascent to 50 ft. 5. OXYGEN breathing commences on arrival at 50 FEET STOP and for the remainder of the decompression time. 6. ASCENT times are NOT INCLUDED in STOPS but are additive.
140'	-	26	3	20	"	
130'	-	30½	4	"	"	
120'	-	36	5	"	"	
110'	-	43½	7	"	"	
100'	-	51	7	"	"	
90'	-	59½	8	"	"	
80'	-	69	9	"	"	
70'	-	79½	10	"	"	
60'	-	92	12	"	"	
50'*	-	99½	7	"	*OXYGEN	
40'	-	107	7	"	"	

TABLE I

350 FEET FOR 15 MINUTES (CONTINUED)

DEPTH IN FEET	TIME (MINS)		STOP TIME (MINS)	RATE OF ASCENT (FT/MIN)	GAS	NOTES
	ARRIVE	LEAVE				
30'	-	117½	10	20	OXYGEN	7. Time on 10/80 - 18 mins. Time on 20/80 - 73½ mins. Time on OXYGEN - 62½ mins.
20'	-	132	14	"	"	
10'	-	154½	22	"	"	
0'	155			"	"	

TABLE I

400 FEET FOR 15 MINUTES ON 10% OXYGEN 90% HELIUM CHANGING TO 20% OXYGEN 80% HELIUM ON ASCENT TO 200 FEET, AND TO OXYGEN AT 50 FEET.

DEPTH IN FEET	TIME (MINS)		STOP TIME (MINS)	RATE OF ASCENT (FT/MIN)	GAS	NOTES
	ARRIVE	LEAVE				
0'	-	0			AIR	COMPRESSION 1. Descent rate NOT TO EXCEED 100 ft/min. 2. On reaching 100 ft divers will change to 10/90 OXY-HELIUM.
100'*	1	-			*10/90	
400'	4	15			"	
200'*	19	22	3	50	*20/80	DECOMPRESSION 3. Ascent rate to be approximately 50 ft/min to 1st STOP (200') and thereafter 20 ft/min between subsequent STOPS. 4. On ascent to 200 ft divers will change to 20/80 OXY-HELIUM and remain on this mixture until ascent to 50 ft. 5. OXYGEN breathing commences on arrival at 50 FEET STOP and for the remainder of the decompression time.
180'	-	27	4	20	"	
160'	-	37	9	20	"	
150'	-	43½	6	"	"	
140'	-	51	7	"	"	
130'	-	59½	8	"	"	
120'	-	69	9	"	"	
110'	-	79½	10	"	"	
100'	-	91	11	"	"	
90'	-	102½	11	"	"	
80'	-	115	12	"	"	
70'	-	129½	14	"	"	

TABLE I

400 FEET FOR 15 MINUTES (CONTINUED)

DEPTH IN FEET	TIME (MINS)		STOP TIME (MINS)	RATE OF ASCENT (FT/MIN)	GAS	NOTES
	ARRIVE	LEAVE				
60'	-	145	15	20	20/80	6. ASCENT times are NOT INCLUDED in STOPS but are additive.
50'*	-	152½	7	"	*OXYGEN	7. Time on 10/90 - 18 mins. Time on 20/80 - 126½ mins. Time on OXYGEN - 63½ mins.
40'	-	160	7	"	"	
30'	-	170½	10	"	"	
20'	-	186	15	"	"	
10'	-	208½	22	"	"	
0'	209			"	"	

TABLE I

450 FEET FOR 15 MINUTES ON 10% OXYGEN 90% HELIUM, CHANGING TO 20% OXYGEN 80% HELIUM ON ASCENT TO 240 FEET AND TO OXYGEN AT 50 FEET

DEPTH IN FEET	TIME (MINS)		STOP TIME (MINS)	RATE OF ASCENT (FT/MIN)	GAS	NOTES
	ARRIVE	LEAVE				
0'	-	0			AIR	COMPRESSION 1. Descent rate NOT TO EXCEED 100 ft/min. 2. On reaching 100 ft divers will change to 10/90 OXY-HELIUM
100'*	1	-			*10/90	
450'	4½	15			"	
240'*	19½	22½	3	50	*20/80	DECOMPRESSION 3. Ascent rate to be approximately 50 ft/min to 1st STOP (240') and thereafter 20 ft/min between subsequent STOPS. 4. On ascent to 240 ft Divers will change to 20/80 OXY-HELIUM and remain on this mixture until ascent to 50 FEET.
220'	-	28½	5	20	"	
200'	-	37½	8	20	"	
190'	-	44	6	"	"	
180'	-	51½	7	"	"	
170'	-	59	7	"	"	
160'	-	67½	8	"	"	
150'	-	77	9	"	"	
140'	-	87½	10	"	"	
130'	-	99	11	"	"	
120'	-	111½	12	"	"	
110'	-	124	12	"	"	

450 FEET FOR 15 MINUTES (CONTINUED)

DEPTH IN FEET	TIME (MINS) ARRIVE	TIME (MINS) LEAVE	STOP TIME (MINS)	RATE OF ASCENT (FT/MIN)	GAS	NOTES
100'	-	138½	14	20	20/80	5. OXYGEN breathing commences on arrival at 50 FEET STOP and for the remainder of the decompression time. 6. ASCENT times are NOT INCLUDED in STOPS but are additive. 7. Time on 10/90 - 18½ mins. Time on 20/80 - 183½ mins. Time on OXYGEN - 84½ mins.
90'	-	154	15	"	"	
80'	-	169½	15	"	"	
70'	-	186	16	"	"	
60'	-	202½	16	"	"	
50'*	-	211	8	"	*OXYGEN	
40'	-	222½	11	"	"	
30'	-	238	15	"	"	
20'	-	258½	20	"	"	
10'	-	287	28	"	"	
0'	287½			"	"	

TABLE I

500 FEET FOR 15 MINUTES ON 10% OXYGEN 90% HELIUM, CHANGING TO 20% OXYGEN 80% HELIUM ON ASCENT TO 250 FEET AND TO OXYGEN AT 50 FEET.

DEPTH IN FEET	TIME (MINS)		STOP TIME (MINS)	RATE OF ASCENT (FT/MIN)	GAS	NOTES
	ARRIVE	LEAVE				
0'	-	0			AIR	COMPRESSION 1. Descent rate NOT TO EXCEED 100 ft/min. 2. On reaching 100 ft divers will change to 10/90 OXY-HELIUM
100'*	1	-			*10/90	
500'	5	15			"	
290'	19½	22½	3	50	10/90	DECOMPRESSION 3. Ascent rate to be approximately 50 ft/min to 1st STOP (290') and thereafter 20 ft/min between subsequent STOPS. 4. On ascent to 250 ft divers will change to 20/80 OXY-HELIUM and remain on this mixture until ascent to 50 FEET.
270'	-	26½	3	20	"	
250'*	-	35½	8	20	*20/80	
240'	-	41	5	"	"	
230'	-	46½	5	"	"	
220'	-	53	6	"	"	
210'	-	61½	8	"	"	
200'	-	70	8	"	"	
190'	-	79½	9	"	"	
180'	-	89	9	"	"	
170'	-	99½	10	"	"	
160'	-	111	11	"	"	

500 FEET FOR 15 MINUTES (CONTINUED)

DEPTH IN FEET	TIME (MINS)		STOP TIME (MINS)	RATE OF ASCENT (FT/MIN)	GAS	NOTES
	ARRIVE	LEAVE				
150'	-	122½	11	20	20/80	5. OXYGEN breathing commences on arrival at 50 FEET STOP and for the remainder of the decompression time.
140'	-	135	12	"	"	
130'	-	149½	14	"	"	6. ASCENT times are NOT INCLUDED in STOPS but are additive.
120'	-	164	14	"	"	7. Time on 10/90 - 26 mins.
110'	-	178½	14	"	"	Time on 20/80 - 238½ mins.
100'	-	195	16	"	"	Time on OXYGEN - 84½ mins.
90'	-	211½	16	"	"	
80'	-	229	17	"	"	
70'	-	246½	17	"	"	
60'	-	265	18	"	"	
50'*	-	273½	8	"	*OXYGEN	
40'	-	285	11	"	"	
30'	-	300½	15	"	"	
20'	-	321	20	"	"	
10'	-	349½	28	"	"	
0'	350			"	"	

34. If the bottom time is exceeded accidentally a 1 minute excess should not cause undue alarm, but any time in excess of this will give a marked increase in the risks of decompression sickness. Move to the next deeper schedule unless the bottom time has been exceeded by 5 mins, in which case an appropriate 1 hour schedule must be used (see Part II).

35. If the diver exceeds the anticipated diving depth then decompress according to the next deeper schedule but when using the maximum depth table of 500 feet, the diver must keep at a pressure less than 510 feet. If 510 feet is exceeded accidentally then the diver must be recalled immediately and decompression commenced without delay to minimise the risks of decompression sickness.

36. Oxygen poisoning, vomiting into the face masks, or failure of the proper gas supply are three important situations leading to removal of the breathing gear and transfer to chamber air breathing. At pressures in excess of 300 feet such a change in breathing mixture will cause dizziness and lack of concentration after a 1 minute delay period. If such an enevtuality occurs decompress as soon as possible using the EMERGENCY AIR BREATHING TABLE 2. below

TABLE 2

EMERGENCY AIR BREATHING

Air Breathing

If it is necessary to breathe air continuously decompress as soon as possible using the following routine:-

a. Continue stoppages as though still on the appropriate oxy-helium schedule until 100 feet is reached.

b. At 100 feet the following stoppages commence:-

DEPTH (FEET)	TIME (MINS)
100'	18
90'	20
80'	22
70'	24
60'	27
50'	30
40'	40
30'	55
20'	75
10'	110

c. In the event of an emergency which requires air at depths less than 100 feet transfer to the above tables at the appropriate stop.

PART II

1 HOUR AND 4 HOUR DURATION DIVES

PRACTICAL CONSIDERATIONS

37. For these dives it is no longer possible to use breathing apparatus in a chamber compressed only with air. The diver must be surrounded by an oxy-helium atmosphere, and this inevitably results in a number of additional requirements which must be met.

38. The oxygen pressure used in the schedules given below never exceeds 0.5 atmospheres and it is assumed that a life support system will be provided to ensure that the carbon dioxide and nitrogen content are kept as recommended.

39. With regard to the temperature and humidity, it is difficult to state the precise requirements owing to the great thermal conductivity of helium and the dependence of heat loss on the absolute pressure. The nature of the exposure is all-important in determining comfort and as there are a number of different diving systems and a number of different life support systems with which they may be coupled, no single set of rules will cover all eventualities. For guidance, as to the nature of the difficulties and how they may be overcome an outline of the system used by the Royal Navy will be given.

40. The RN system consists of a relatively small two-man submersible chamber which can be raised and lowered to depth, either as an observation chamber or with the bottom door open, as a small diving bell. The bottom door can be locked at any pressure up to the maximum permitted working pressure and the chamber can be raised at great speed through the water and then locked on to a much larger deck decompression chamber. The divers may then transfer under pressure from the submersible chamber into the deck chamber. This technique has the marked advantage that the divers spend only the working time in the water and all the decompression is carried out in comfort on the ship.

41. The deck compression chamber must have a double compartment and small service lock, all capable of attaining the maximum working pressure.

42. With this system of diving it is possible for a man to be working at 600 feet and then five to eight minutes later to be back in the large deck chamber taking refreshment or being decompressed. This is a marked advantage in deep diving because in most waters of the world once a depth of 300 feet is exceeded it is very cold and men cannot endure long working periods in the water.

43. It is impractical with the diving suits at present in use to consider a single dive of greater duration than one hour, but this is not a severe disadvantage with the highly mobile submersible diving chamber system used by the Royal Navy.

44. At the commencement of a dive the chamber is filled with a respirable mixture of oxy-helium. This is easily accomplished by displacing the heavy air by the light helium mixture. It is possible to see the interface between the two gases if some form of interface indicator can be used, eg. a balloon filled with pure helium, will float on top of the dense air layer. Consequently, the chamber can be flushed out with oxy-helium gas with little or no loss of valuable helium. The chamber is then lowered to depth with the bottom door open. The rate of descent is at 50 feet per minute, so that for example 500 feet can be reached in ten

minutes. As the water commences to rise through the open bottom door of the submersible chamber, gas supplied via an umbilical pipe and controlled by the diver from an internal inlet valve is blown into the chamber to ensure that the depth of water inside the chamber does not exceed 2 feet. The correct breathing gas mixture at depth can be obtained in a variety of ways. For example, it is possible to flush out the chamber with 20% oxygen 80% helium at atmospheric pressure, pressurise on 10% oxygen 90% helium to 100 feet and then add helium for the remainder of the compression.

45. Clearly, gas mixing and accurate gas analysis are important requirements for atmosphere control, otherwise one cannot move from one gas composition to another with confidence. Once the divers are at depth breathing the appropriate mixture, they can put on their breathing sets supplied by gas from bottle banks attached to the submersible chamber. This means that from the diver's safety point of view he now has two independent sources of breathing mixture, ie. one from the ship-borne pressure banks and the other from his own immediate submersible chamber banks. In addition, it is wise to have a sufficient reserve capacity of gas actually on the diver's back to allow him to return to the submersible chamber, if, for some reason his main gas supply is cut off. The psychological benefit to the diver of this triple safety measure cannot be over-stated.

46. In view of the fact that at most only one diver is permanently stationed inside the submersible chamber and that for reasons stated earlier he is unlikely to be there for more than one hour, it is not necessary to consider oxygen replenishment of the submersible chamber.

47. The large ship-borne chamber is pressurised to the dive with the same gas composition as that provided in the submersible chamber. Following completion of the dive, the decompression inside this chamber will probably take many hours or even days. Obviously then, a thorough and reliable life support system is essential. Matters for particular attention are, good humidity and carbon dioxide control, adequate room for sleeping, exercising, toilet and washing facilities, recreation and the ability to replace large (eg. bedding) or small (eg. cups of coffee) items at will through the lock system.

48. Attention must be drawn to the need to replenish oxygen during the various stages of decompression. The percentage given on the schedules must be such that they are within the tolerances stated in the tables.

49. It must be re-emphasised that no dives of this nature are free from hazard and reference must be made to the therapy tables if any untoward incidents arise during the decompression.

PART II

1 HOUR AND 4 HOUR DURATION DIVES

USE OF THE TABLES (3 and 4)

50. Only by the strict observance of all procedures and stoppages during descent and ascent, as specified for the conditions of each particular dive, can maximum safety and the minimum possibility of decompression sickness be achieved.

51. The maximum bottom durations given in the Tables must not be exceeded.

52. Time on the bottom and decompression stops are in hours.

53. The correct breathing gas mixture at depth and during decompression must be kept within the limits as stated in Table 5.

54. The oxygen partial pressure must not exceed 0.5 ~~ATA~~.

55. The carbon dioxide partial pressure must not exceed 0.5% ~~of one~~ atmosphere ~~absolute.~~

56. The nitrogen content of the mixture breathed must not exceed 2% of the total gas pressure.

57. The humidity and temperature must be adjusted to ensure comfort.

58. The bottom time is taken as the time between leaving the surface and leaving the bottom.

59. All descents to depth are not to exceed 50 feet per minute.

60. All ascents from depth to the first stop are not to exceed 50 feet per minute.

61. The rate of ascent between stops varies and is given in a separate column for the various depths on each particular schedule.

62. Time spent moving from one stop to another is quite short and is included in the stop times, except for the final pressure change from 10 feet to the surface.

63. Attention must be drawn to the importance of accurate gas mixing and analysis.

64. For current RN Recompression procedures see Appendix I Pages

TABLE 3

200 FEET FOR 1 HOUR

Bradley Equipment, 0.5 ATA Oxygen Remainder Helium

DEPTH IN FEET	ELAPSED TIME (HRS & MINS) ARRIVE	ELAPSED TIME (HRS & MINS) LEAVE	STOP TIME HOURS	RATE OF ASCENT (FT/MIN)	NOTES
0'	-	00.00.			COMPRESSION 1. DESCENT RATE NOT TO EXCEED 50 FT/MIN. 2. During COMPRESSION/DECOMPRESSION the required oxygen partial pressure is 0.5 ATA and must always be kept within the limits as stated in Table 5.
100'	00.02	-			
200'	00.04	01.00			
105'	01.02	01.30	½	50	DECOMPRESSION 3. ASCENT RATES to be approx. 50 FT/MIN to 1st STOP (105') 30 FT/MIN to 2nd STOP (75') 25 FT/MIN to 3rd STOP (50') 20 FT/MIN to 4th STOP (30') and thereafter 10 FT/MIN between STOPS. 4. ASCENT times are included in the STOP times except for the final pressure change from 10 ft to surface. 5. Carbon dioxide (CO_2) to be maintained at less than 0.5% effective concentrations at sea level (1 ATM) TABLE 5. 6. TOTAL TIME OF DIVE - 5 HRS 16 mins. DECOMPRESSION TIME - 4 HRS 16 mins.
75'	-	02.15	¾	30	
50'	-	03.00	¾	25	
30'	-	03.45	¾	20	
20'	-	04.30	¾	10	
10'	-	05.15	¾	10	
0'	05.16				

TABLE 3

250 FEET FOR 1 HOUR

DEPTH IN FEET	ELAPSED TIME (HRS & MINS)		STOP TIME HOURS	RATE OF ASCENT (FT/MIN)	NOTES
	ARRIVE	LEAVE			
0'		00.00			COMPRESSION 1. DESCENT RATE NOT TO EXCEED 50 FT/MIN. 2. During COMPRESSION/DECOMPRESSION the required oxygen partial pressure is 0.5 ATA and must always be kept within the limits as stated in TABLE 5.
100'	00.02	-			
250'	00.05	01.00			
140'	01.02½	01.30	½	50	DECOMPRESSION 3. ASCENT RATES to be approx. 50 FT/MIN to 1st STOP (140') 40 FT/MIN to 2nd STOP (100') 30 FT/MIN to 3rd STOP (70') 20 FT/MIN to 4th STOP (50') 20 FT/MIN to 5th STOP (30') and thereafter 10 FT/MIN between STOPS. 4. ASCENT times are included in the STOP times except for the final pressure change from 10 ft to surface. 5. Carbon dioxide (CO_2) to be maintained at less than 0.5% effective concentrations at sea level (1ATM) TABLE 5. 6. TOTAL TIME OF DIVE - 7 HRS 31 MINS. DECOMPRESSION TIME - 6 HRS 31 MINS.
100'	-	02.30	1	40	
70'	-	03.30	1	30	
50'	-	04.30	1	20	
30'	-	05.30	1	20	
20'	-	06.30	1	10	
10'	-	07.30	1	10	
0'	07.31				

TABLE 3

300 FEET FOR 1 HOUR

DEPTH IN FEET	ELAPSED TIME (HRS & MINS) ARRIVE	ELAPSED TIME (HRS & MINS) LEAVE	STOP TIME HOURS	RATE OF ASCENT (FT/MIN)	NOTES
0'		00.00			COMPRESSION 1. DESCENT RATE NOT TO EXCEED 50 FT/MIN. 2. During COMPRESSION/DECOMPRESSION the required oxygen partial pressure is 0.5 ATA and must always be kept within the limits as stated in TABLE 5.
100'	00.02	-			
300'	00.06	01.00			
180'	01.02½	01.30	½	50	DECOMPRESSION 3. ASCENT RATES to be approx. 50 FT/MIN to 1st STOP (180') 50 FT/MIN to 2nd STOP (130') 35 FT/MIN to 3rd STOP (95') 30 FT/MIN to 4th STOP (65') 20 FT/MIN to 5th STOP (45') 15 FT/MIN to 6th STOP (30') and thereafter 10 FT/MIN between STOPS. 4. ASCENT times are included in the STOP times except for the final pressure change from 10 ft to surface. 5. Carbon dioxide (CO_2) to be maintained at less than 0.5% effective concentrations at sea level (1 ATM) TABLE 5. 6. TOTAL TIME OF DIVE - 10 HRS 1 MIN DECOMPRESSION TIME - 9 HRS 1 MIN
130'	-	03.00	1½	50	
95'	-	04.30	1½	35	
65'	-	06.00	1½	30	
45'	-	07.00	1	20	
30'	-	08.00	1	15	
20'	-	09.00	1	10	
10'	-	10.00	1	10	
0'	10.01				

TABLE 3

350 FEET FOR 1 HOUR

DEPTH IN FEET	ELAPSED TIME (HRS & MINS) ARRIVE	ELAPSED TIME (HRS & MINS) LEAVE	STOP TIME HOURS	RATE OF ASCENT (FT/MIN)	NOTES
0'	-	00.00			COMPRESSION 1. DESCENT RATE NOT TO EXCEED 50 FT/MIN. 2. During COMPRESSION/DECOMPRESSION the required oxygen partial pressure is 0.5% ATA and must always be kept within the limits as stated in TABLE 5.
100'	00.02	-			
350'	00.07	01.00			
220'	01.03	01.30	½	50	DECOMPRESSION 3. ASCENT RATES to be approx. 50 FT/MIN to 1st STOP (220') 45 FT/MIN to 2nd STOP (165') 45 FT/MIN to 3rd STOP (120') 35 FT/MIN to 4th STOP (85') 25 FT/MIN to 5th STOP (60') 20 FT/MIN to 6th STOP (40') and thereafter 10 FT/MIN between STOPS. 4. ASCENT times are included in the STOP times except for the final pressure change from 10 FT to surface. 5. Carbon dioxide (CO_2) to be maintained at less than 0.5% effective concentrations at sea level (1 ATM) TABLE 5. 6. TOTAL TIME OF DIVE-13 HRS 31min DECOMPRESSION TIME-12 HRS 31min
165'	-	03.00	1½	45	
120'	-	05.00	2	45	
85'	-	07.00	2	35	
60'	-	09.00	2	25	
40'	-	10.30	1½	20	
30'	-	11.30	1	10	
20'	-	12.30	1	10	
10'	-	13.30	1	10	
0'	13.31				

TABLE 3

400 FEET FOR 1 HOUR

DEPTH IN FEET	ELAPSED TIME (HRS & MINS) ARRIVE	ELAPSED TIME (HRS & MINS) LEAVE	STOP TIME HOURS	RATE OF ASCENT (FT/MIN)	NOTES
0'	-	00.00			COMPRESSION 1. DESCENT RATE NOT TO EXCEED 50 FT/MIN.
100'	00.02				2. During COMPRESSION/DECOMPRESSION the required oxygen partial pressure is 0.5 ATA and must always be kept within the limits as stated in TABLE 5.
400'	00.08	01.00			
265'	01.03	01.30	½	50	DECOMPRESSION 3. ASCENT RATES to be approx. 50 FT/MIN to 1st STOP (265') 50 FT/MIN to 2nd STOP (200') 50 FT/MIN to 3rd STOP (150') 40 FT/MIN to 4th STOP (110') 30 FT/MIN to 5th STOP (80') 25 FT/MIN to 6th STOP (55') 20 FT/MIN to 7th STOP (35') 15 FT/MIN to 8th STOP (20') and thereafter 10 FT/MIN between STOPS.
200'	-	03.30	2	50	
150'	-	05.30	2	50	
110'	-	08.00	2½	40	
80'	-	10.30	2½	30	
55'	-	12.30	2	25	4. ASCENT times are included in the STOP times except for the final pressure change from 10 FT to surface.
35'	-	14.30	2	20	5. Carbon dioxide (CO_2) to be maintained at less than 0.5% effective concentrations at sea level (1 ATM) TABLE 5.
20'	-	16.00	1½	15	6. TOTAL TIME OF DIVE - 17 HRS 31 mins DECOMPRESSION TIME - 16 HRS 31 mins
10'	-	17.30	1½	10	
0'	17.31				

TABLE 3

450 FEET FOR 1 HOUR

DEPTH IN FEET	ELAPSED TIME (HRS & MINS)		STOP TIME HOURS	RATE OF ASCENT (FT/MIN)	NOTES
	ARRIVE	LEAVE			
0'	-	00.00			COMPRESSION 1. DESCENT RATE NOT TO EXCEED 50 FT/MIN.
100'	00.02	-			2. During COMPRESSION/DECOMPRESSION the required oxygen partial pressure is 0.5 ATA and must always be kept within the limits as stated in TABLE 5.
450'	00.09	01.00			
305'	01.03	01.30	½	50	DECOMPRESSION 3. ASCENT RATES to be approx. 50 FT/MIN to 1st STOP (305') 50 FT/MIN to 2nd STOP (230') 50 FT/MIN to 3rd STOP (170') 45 FT/MIN to 4th STOP (125') 35 FT/MIN to 5th STOP (90') 25 FT/MIN to 6th STOP (65') 20 FT/MIN to 7th STOP (45') 15 FT/MIN to 8th STOP (30') and thereafter 10 FT/MIN between STOPS. 4. ASCENT times are included in the STOP times except for the final pressure change from 10 FT to surface. 5. Carbon dioxide (CO_2) to be maintained at less than 0.5% effective concentrations at sea level (1 ATM) TABLE 5. 6. TOTAL TIME OF DIVE - 21 HRS 31 MINS DECOMPRESSION TIME - 20 HRS 31 MINS
230'	-	03.30	2	50	
170'	-	06.30	3	50	
125'	-	09.30	3	45	
90'	-	12.30	3	35	
65'	-	15.00	2½	25	
45'	-	17.00	2	20	
30'	-	18.30	1½	15	
20'	-	20.00	1½	10	
10'	-	21.30	1½	10	
0'	21.31				

TABLE 3

500 FEET FOR 1 HOUR

DEPTH IN FEET	ELAPSED TIME (HRS & MINS)		STOP TIME HOURS	RATE OF ASCENT (FT/MIN)	NOTES
	ARRIVE	LEAVE			
0'	-	00.00			COMPRESSION 1. DESCENT RATE NOT TO EXCEED 50FT/MIN 2. During COMPRESSION/DECOMPRESSION the required oxygen partial pressure is 0.5 ATA and must always be kept within the limits as stated in TABLE 5.
100'	00.02	-			
500'	00.10	01.00			
350'	01.03	01.30	½	50	DECOMPRESSION 3. ASCENT RATES to be approx. 50 FT/MIN to 1st STOP (350') 50 FT/MIN to 2nd STOP (265') 50 FT/MIN to 3rd STOP (200') 50 FT/MIN to 4th STOP (150') 40 FT/MIN to 5th STOP (110') 30 FT/MIN to 6th STOP (80') 25 FT/MIN to 7th STOP (55') 20 FT/MIN to 8th STOP (35') 15 FT/MIN to 9th STOP (20') and thereafter 10 FT/MIN between STOPS. 4. ASCENT times are included in the STOP times except for the final pressure change from 10 FT to surface. 5. Carbon dioxide (CO_2) to be maintained at less than 0.5% effective concentrations at sea level (1 ATM) TABLE 5. 6. TOTAL TIME OF DIVE - 26 HRS 31 MINS DECOMPRESSION TIME - 25 HRS 31 MINS
265'	-	04.00	2½	50	
200'	-	07.30	3½	50	
150'	-	11.00	3½	50	
110'	-	14.30	3½	40	
80'	-	17.30	3	30	
55'	-	20.00	2½	25	
35'	-	22.30	2½	20	
20'	-	24.30	2	15	
10'	-	26.30	2	10	
0'	26.31				

TABLE 4

200 FEET FOR 4 HOURS

DEPTH IN FEET	ELAPSED TIME (HRS & MINS) ARRIVE	ELAPSED TIME (HRS & MINS) LEAVE	STOP TIME HOURS	RATE OF ASCENT (FT/MIN)	NOTES
0'	-	00.00			COMPRESSION 1. DESCENT RATE NOT TO EXCEED 50 FT/MIN
100'	00.02	-			2. During COMPRESSION/DECOMPRESSION the required oxygen partial pressure is 0.5 ATA and must always be kept within the limits as stated in TABLE 5.
200'	00.04	04.00			
105'	04.02	09.00	5	50	DECOMPRESSION 3. ASCENT RATES to be approx. 50 FT/MIN to 1st STOP (105') 30 FT/MIN to 2nd STOP (75') 25 FT/MIN to 3rd STOP (50') 20 FT/MIN to 4th STOP (30') and thereafter 10 FT/MIN between STOPS.
75'	-	13.00	4	30	
50'	-	17.00	4	25	
30'	-	21.00	4	20	4. ASCENT times are included in the STOP times except for the final pressure change from 10 FT to surface.
20'	-	23.30	2½	10	5. Carbon dioxide (CO_2) to be maintained at less than 0.5% effective concentrations at sea level (1 ATM) TABLE 5.
10'	-	28.00	4½	10	
0'	28.01				6. TOTAL TIME OF DIVE - 28 HRS 1 MIN DECOMPRESSION TIME - 24 HRS 1 MIN

TABLE 4

250 FEET FOR 4 HOURS

DEPTH IN FEET	ELAPSED TIME (HRS & MINS) ARRIVE	ELAPSED TIME (HRS & MINS) LEAVE	STOP TIME HOURS	RATE OF ASCENT (FT/MIN)	NOTES
0'	-	00.00			COMPRESSION 1. DESCENT RATE NOT TO EXCEED 50 FT/MIN.
100'	00.02	-			2. During COMPRESSION/DECOMPRESSION the required oxygen partial pressure is 0.5 ATA and must always be kept within the limits as stated in TABLE 5.
250'	00.05	04.00			
140'	04.02½	09.00	5	50	DECOMPRESSION 3. ASCENT RATES to be approx. 50 FT/MIN to 1st STOP (140') 40 FT/MIN to 2nd STOP (100') 30 FT/MIN to 3rd STOP (70') 20 FT/MIN to 4th STOP (50') 20 FT/MIN to 5th STOP (30') and thereafter 10 FT/MIN between STOPS. 4. ASCENT times are included in the STOP times except for the final pressure change from 10 FT to surface. 5. Carbon dioxide (CO_2) to be maintained at less than 0.5% effective concentrations at sea level (1 ATM) TABLE 5. 6. TOTAL TIME OF DIVE - 34 HRS 1 MIN DECOMPRESSION TIME - 30 HRS 1 MIN
100'	-	14.00	5	40	
70'	-	19.00	5	30	
50'	-	23.00	4	20	
30'	-	27.00	4	20	
20'	-	29.30	2½	10	
10'	-	34.00	4½	10	
0'	34.01				

TABLE 4

300 FEET FOR 4 HOURS

Breathing Mixture 0.5 Atm Oxygen Remainder Helium

DEPTH IN FEET	ELAPSED TIME (HRS & MINS)		STOP TIME HOURS	RATE OF ASCENT (FT/MIN)	NOTES
	ARRIVE	LEAVE			
0'	-	00.00			COMPRESSION 1. DESCENT RATE NOT TO EXCEED 50 FT/MIN.
100'	00.02	-			2. During COMPRESSION/DECOMPRESSION the required oxygen partial pressure is 0.5 ATA and must always be kept within the limits as stated in TABLE 5.
300'	00.06	04.00			
180'	04.02½	09.00	5	50	DECOMPRESSION 3. ASCENT RATES to be approx. 50 FT/MIN to 1st STOP (180') 50 FT/MIN to 2nd STOP (130') 35 FT/MIN to 3rd STOP (95') 30 FT/MIN to 4th STOP (65') 20 FT/MIN to 5th STOP (45') 15 FT/MIN to 6th STOP (30') and thereafter 10 FT/MIN between STOPS.
130'	-	15.00	6	50	
95'	-	20.30	5½	35	
65'	-	25.30	5	30	
45'	-	29.30	4	20	4. ASCENT times are included in the STOPS time except for the final pressure change from 10 FT to surface.
30'	-	33.00	3½	15	
20'	-	35.00	2	10	5. Carbon dioxide (CO_2) to be maintained at less than 0.5% effective concentrations at sea level (1 ATM) TABLE 5.
10'	-	40.00	5	10	6. TOTAL TIME OF DIVE - 40 HRS 1 MIN. DECOMPRESSION TIME - 36 HRS 1 MIN.
0'	40.01				

TABLE 4

350 FEET FOR 4 HOURS

DEPTH IN FEET	ELAPSED TIME (HRS & MINS) ARRIVE	ELAPSED TIME (HRS & MINS) LEAVE	STOP TIME HOURS	RATE OF ASCENT (FT/MIN)	NOTES
0'	-	00.00			COMPRESSION 1. DESCENT RATE NOT TO EXCEED 50 FT/MIN.
100'	00.02	-			2. During COMPRESSION/DECOMPRESSION the required oxygen partial pressure is 0.5 ATA and must always be kept within the limits as stated in TABLE 5.
350'	00.07	04.00			
220'	04.03	09.00	5	50	DECOMPRESSION 3. ASCENT RATES to be approx. 50 FT/MIN to 1st STOP (220') 45 FT/MIN to 2nd STOP (165') 45 FT/MIN to 3rd STOP (120') 35 FT/MIN to 4th STOP (85') 25 FT/MIN to 5th STOP (60') 20 FT/MIN to 6th STOP (40') and thereafter 10 FT/MIN between STOPS.
165'	-	15.00	6	45	
120'	-	21.30	6½	45	
85'	-	27.30	6	35	
60'	-	32.30	5	25	4. ASCENT times are included in the STOP times except for the final pressure change from 10 FT to surface.
40'	-	36.30	4	20	
30'	-	39.00	2½	10	5. Carbon dioxide (CO_2) to be maintained at less than 0.5% effective concentrations at sea level (1 ATM) TABLE 5.
20'	-	41.30	2½	10	6. TOTAL TIME OF DIVE - 46 HRS 1 MIN. DECOMPRESSION TIME - 42 HRS 1 MIN.
10'	-	46.00	4½	10	
0'	46.01				

TABLE 4

400 FEET FOR 4 HOURS

DEPTH IN FEET	ELAPSED TIME (HRS & MINS)		STOP TIME HOURS	RATE OF ASCENT (FT/MIN)	NOTES
	ARRIVE	LEAVE			
0'	-	00.00			COMPRESSION 1. DESCENT RATE NOT TO EXCEED 50 FT/MIN.
100'	00.02	-			2. During COMPRESSION/DECOMPRESSION the required oxygen partial pressure is 0.5 ATA and must be kept within the limits as stated in TABLE 5.
400'	00.08	04.00			
265'	04.03	09.00	5	50	DECOMPRESSION 3. ASCENT RATES to be approx. 50 FT/MIN to 1st STOP (265') 50 FT/MIN to 2nd STOP (200') 50 FT/MIN to 3rd STOP (150') 40 FT/MIN to 4th STOP (110') 30 FT/MIN to 5th STOP (80') 25 FT/MIN to 6th STOP (55') 20 FT/MIN to 7th STOP (35') 15 FT/MIN to 8th STOP (20') and thereafter 10 FT/MIN between STOPS.
200'	-	15.30	6½	50	
150'	-	22.30	7	50	
110'	-	29.00	6½	40	
80'	-	34.30	5½	30	
55'	-	39.30	5	25	4. ASCENT times are included in the STOP times except for the final pressure change from 10 FT to surface.
35'	-	44.00	4½	20	5. Carbon dioxide (CO_2) to be maintained at less than 0.5% effective concentrations at sea level (1 ATM) TABLE 5.
20'	-	47.30	3½	15	6. TOTAL TIME OF DIVE - 52 HRS 1 MIN. DECOMPRESSION TIME - 48 HRS 1 MIN.
10'	-	52.00	4½	10	
0'	52.01				

TABLE 4

450 FEET FOR 4 HOURS

DEPTH IN FEET	ELAPSED TIME (HRS & MINS) ARRIVE	ELAPSED TIME (HRS & MINS) LEAVE	STOP TIME HOURS	RATE OF ASCENT (FT/MIN)	NOTES
0'	-	00.00			COMPRESSION 1. DESCENT RATE NOT TO EXCEED 50 FT/MIN
100'	00.02	-			2. During COMPRESSION/DECOMPRESSION the required oxygen partial pressure is 0.5 ATA and must always be kept within the limits as stated in TABLE 5.
450'	00.09	04.00			
305'	04.03	09.00	5	50	DECOMPRESSION 3. ASCENT RATES to be approx. 50 FT/MIN to 1st STOP (305') 50 FT/MIN to 2nd STOP (230') 50 FT/MIN to 3rd STOP (170') 45 FT/MIN to 4th STOP (125') 35 FT/MIN to 5th STOP (90') 25 FT/MIN to 6th STOP (65') 20 FT/MIN to 7th STOP (45') 15 FT/MIN to 8th STOP (30') and thereafter 10 FT/MIN between STOPS.
230'	-	16.30	7½	50	
170'	-	24.30	8	50	
125'	-	32.00	7½	45	
90'	-	38.30	6½	35	
65'	-	43.30	5	25	4. ASCENT times are included in the STOP times except for the final pressure change from 10 FT to surface.
45'	-	47.30	4	20	5. Carbon dioxide (CO_2) to be maintained at less than 0.5% effective concentrations at sea level (1 ATM) TABLE 5.
30'	-	51.00	3½	15	6. TOTAL TIME OF DIVE - 58 HRS 1 MIN DECOMPRESSION TIME - 54 HRS 1 MIN
20'	-	53.30	2½	10	
10'	-	58.00	4½	10	
0'	58.01				

TABLE 4

500 FEET FOR 4 HOURS

DEPTH IN FEET	ELAPSED TIME (HRS & MINS)		STOP TIME HOURS	RATE OF ASCENT (FT/MIN)	NOTES
0'	-	00.00			COMPRESSION 1. DESCENT RATE NOT TO EXCEED 50 FT/MIN. 2. During COMPRESSION/DECOMPRESSION the required oxygen partial pressure is 0.5 ATA and must always be kept within the limits as stated in TABLE 5.
100'	00.02	-			
500'	00.10	04.00			
350'	04.03	09.00	5	50	DECOMPRESSION 3. ASCENT RATES to be approx. 50 FT/MIN to 1st STOP (350') 50 FT/MIN to 2nd STOP (265') 50 FT/MIN to 3rd STOP (200') 50 FT/MIN to 4th STOP (150') 40 FT/MIN to 5th STOP (110') 30 FT/MIN to 6th STOP (80') 25 FT/MIN to 7th STOP (55') 20 FT/MIN to 8th STOP (35') 15 FT/MIN to 9th STOP (20') and thereafter 10 FT/MIN between STOPS. 4. ASCENT times are included in the STOP times except for the final pressure change from 10 ft to surface. 5. Carbon dioxide (CO_2) to be maintained at less than 0.5% effective concentrations at sea level (1 ATM) TABLE 5. 6. TOTAL TIME OF DIVE - 64 HRS 1 MIN DECOMPRESSION TIME - 60 HRS 1 MIN
265'	-	16.30	7½	50	
200'	-	25.00	8½	50	
150'	-	33.00	8	50	
110'	-	40.00	7	40	
80'	-	46.00	6	30	
55'	-	51.30	5½	25	
35'	-	56.00	4½	20	
20'	-	59.30	3½	15	
10'	-	64.00	4½	10	
0'	64.01				

TABLE 5

OXYGEN AND CARBON DIOXIDE TOLERANCES

DEPTH (FEET)	DEPTH ABS (FEET)	DEPTH (M)	OXYGEN PERCENTAGES		CO_2 READING AT PRESSURE
			(MIN)	(MAX)	(MAX Page)
500	533	16.15	2.85	3.10	.031
495	528	16.00	2.88	3.13	.031
490	523	15.85	2.91	3.16	.031
485	518	15.70	2.94	3.19	.031
480	513	15.55	2.97	3.22	.032
475	508	15.39	3.00	3.25	.032
470	503	15.24	3.03	3.28	.032
465	498	15.09	3.06	3.31	.033
460	493	14.94	3.10	3.35	.033
455	488	14.79	3.13	3.38	.033
450	483	14.64	3.17	3.42	.034
445	478	14.49	3.20	3.45	.034
440	473	14.33	3.24	3.49	.034
435	468	14.18	3.28	3.53	.035
430	463	14.03	3.31	3.56	.035
425	458	13.88	3.35	3.60	.036
420	453	13.73	3.39	3.64	.036
415	448	13.58	3.43	3.68	.036
410	443	13.43	3.48	3.73	.037
405	438	13.27	3.52	3.77	.037
400	433	13.12	3.56	3.81	.038
395	428	12.97	3.61	3.86	.038
390	423	12.82	3.65	3.90	.039
385	418	12.67	3.70	3.95	.039
380	413	12.52	3.75	4.00	.040
375	408	12.36	3.80	4.05	.040
370	403	12.21	3.85	4.10	.041
365	398	12.06	3.90	4.15	.041
360	393	11.91	3.95	4.20	.042
355	388	11.76	4.00	4.25	.042
350	383	11.61	4.06	4.31	.043
345	378	11.46	4.12	4.37	.043
340	373	11.30	4.17	4.42	.044
335	368	11.15	4.23	4.48	.044

TABLE 5 (Cont'd)

DEPTH GAUGE (FEET)	DEPTH ABS (FEET)	DEPTH ABS (ATA)	OXYGEN PERCENTAGES		CO_2 READING AT PRESSURE
			(MIN)	(MAX)	(MAX %age)
330	363	11.00	4.30	4.55	.045
325	358	10.85	4.36	4.61	.046
320	353	10.70	4.43	4.68	.046
315	348	10.55	4.49	4.74	.047
310	343	10.39	4.56	4.81	.048
305	338	10.24	4.63	4.88	.048
300	333	10.09	4.71	4.96	.049
295	328	9.94	4.78	5.03	.050
290	323	9.79	4.86	5.11	.051
285	318	9.64	4.94	5.19	.051
280	313	9.48	5.02	5.27	.052
275	308	9.33	5.11	5.36	.053
270	303	9.18	5.20	5.45	.054
265	298	9.03	5.29	5.54	.055
260	293	8.88	5.38	5.63	.056
255	288	8.73	5.48	5.73	.057
250	283	8.58	5.58	5.83	.058
245	278	8.42	5.69	5.94	.059
240	273	8.27	5.79	6.04	.060
235	268	8.12	5.91	6.16	.061
230	263	7.97	6.02	6.27	.062
225	258	7.82	6.15	6.40	.064
220	253	7.67	6.27	6.52	.065
215	248	7.51	6.40	6.65	.066
210	243	7.36	6.54	6.79	.067
205	238	7.21	6.68	6.93	.069
200	233	7.06	6.83	7.08	.070
195	228	6.91	6.99	7.24	.072
190	223	6.76	7.15	7.40	.074
185	218	6.61	7.32	7.57	.075
180	213	6.46	7.50	7.75	.077
175	208	6.30	7.68	7.93	.079
170	203	6.15	7.88	8.13	.081
165	198	6.00	8.08	8.33	.083
160	193	5.85	8.30	8.55	.085

TABLE 5 (Cont'd)

DEPTH GAUGE (FEET)	DEPTH ABS (FEET)	DEPTH ABS (ATA)	OXYGEN PERCENTAGES		CO_2 READING AT PRESSURE
			(MIN)	(MAX)	(MAX %age)
155	188	5.70	8.53	8.78	.087
150	183	5.55	8.77	9.02	.090
145	178	5.39	9.02	9.27	.092
140	173	5.24	9.29	9.54	.095
135	168	5.09	9.57	9.82	.098
130	163	4.94	9.87	10.12	.101
125	158	4.79	10.19	10.44	.104
120	153	4.64	10.53	10.78	.107
115	148	4.48	10.90	11.15	.111
110	143	4.33	11.29	11.54	.115
105	138	4.18	11.71	11.96	.119
100	133	4.03	12.16	12.41	.124
95	128	3.88	12.64	12.89	.128
90	123	3.73	13.16	13.41	.134
85	118	3.58	13.73	13.98	.139
80	113	3.42	14.35	14.60	.146
75	108	3.27	15.03	15.28	.152
70	103	3.12	15.77	16.02	.160
65	98	2.97	16.59	16.84	.168
60	93	2.82	17.49	17.74	.177
55	88	2.67	18.50	18.75	.187
50	83	2.51	19.63	19.88	.198
45	78	2.36	20.00	21.00	.211
40	73	2.21	20.00	21.00	.226
35	68	2.06	20.00	21.00	.242
30	63	1.91	20.00	21.00	.261
25	58	1.76	20.00	21.00	.284
20	53	1.61	20.00	21.00	.311
15	48	1.45	20.00	21.00	.343
10	43	1.30	20.00	21.00	.383
5	38	1.15	20.00	21.00	.434
0	33	1.00	20.00	21.00	.500

APPENDIX I

TREATMENT OF DECOMPRESSION SICKNESS FROM OXY-HELIUM DIVING

65. With the use of any oxy-helium diving tables at present available, including these published here, there is a small but inevitable risk of decompression sickness. A copy of the current RN practice for treatment is given in the Air Diving Tables (1968) and these procedures should suffice for all except the rare and serious cases. For the latter it will be necessary to follow the procedure given in this Appendix.

66. WHEN THESE OXY-HELIUM TABLES ARE USED IT IS ESSENTIAL THAT ADEQUATE PROVISION IS MADE FOR THE DIAGNOSIS AND TREATMENT OF DECOMPRESSION SICKNESS.

67. It is essential for the divers and their employers to appreciate that there is an additional risk of aseptic necrosis of bone. This is an occupational hazard of all who work in raised environmental pressures and an annual radiological examination of all divers who use these tables is to be arranged. Full details of the facilities available for these x-rays can be obtained on application to the MRC, Central Registry of Compressed Air Workers, University of Newcastle-upon-Tyne, 20 Claremont Place, Newcastle-upon-Tyne 2.

68. It is impossible to describe all the medical aspects sufficiently in a technical memorandum such as this.

69. In commercial diving it has become accepted that the diver in the first instance, will be treated by his fellow-divers, but the advice of a suitably experienced medical practitioner should always be readily available.

70. The symptoms and signs of decompression sickness have already been summarised in the addendum to the AIR DIVING TABLES previously issued. The manifestations of decompression sickness which follow oxy-helium diving are similar to those which result from air diving.

71. TREAT ALL UNUSUAL MANIFESTATIONS AFTER OR EVEN DURING DECOMPRESSION AS DECOMPRESSION SICKNESS UNTIL PROVED OTHERWISE.

72. Remember that decompression sickness can begin before the diver has reached the surface.

73. TREAT ALL CASES OF DECOMPRESSION SICKNESS, WHETHER THE DIAGNOSIS IS CERTAIN OR DOUBTFUL, BY IMMEDIATE RECOMPRESSION. DELAY CAN BE DANGEROUS AND MAY ALLOW THE ILLNESS TO PROGRESS IRREVERSIBLY. RECOMPRESS TO AT LEAST THE DEPTH OF COMPLETE RELIEF OF ALL THE SYMPTOMS.

74. For divers whose symptoms begin at atmospheric pressure the recompression is most conveniently begun with compressed air. The oxygen-breathing treatment tables already described in the annex to the Air Tables, should be used. If full relief does not occur within ten minutes at 60 ft then further recompression is immediately required. Compressed air is an unsuitable breathing gas at the very great depths that may be needed to alleviate the condition, and because of the difficulties of changing the atmosphere within a chamber when at raised

pressure from that of compressed air to oxy-helium, compressed air is not to be used at depths greater than 60 feet. Conventional recompression to 165 feet with compressed air might cure some cases, but, for the sake of those whose symptoms remain after reaching this depth, further recompression from 60 feet is to be by the addition of pure helium to the chamber. This keeps the partial pressure of oxygen below 0.6 atm whatever depth is reached.

75. Recompression has, on occasion, been required to depths in excess of the original dive. Relief of symptoms has been at depths greater than 450 feet on a number of occasions.

76. It is essential that the recompression facilities are capable of supporting the divers in a reasonable state of comfort at all pressures up to the maximum diving pressure for an indefinite period.

77. The chamber must have at least two compartments so that a medical practitioner may be locked in to attend the diver if necessary. The chamber must be fitted with a complete atmosphere control system, in particular, carbon dioxide analysis and scrubbing, and oxygen analysis and replenishment facilities to monitor and maintain a partial pressure of oxygen of 0.2 to 0.6 atm and a partial pressure of carbon dioxide less than 0.005 atm. For therapeutic purposes there must be a sufficient reserve of helium available at the start of the dive to allow for both compartments to be taken to the maximum pressure from surface on two occasions.

78. Once the pressure at which the maximum possible relief of signs and symptoms has been reached it should be held constant for a period of 30 minutes.

79. Decompression is at the rate indicated in Table 6. This rate is dependent on the depth of relief, the table being entered at that pressure. Faster rates of ascent than Table 6 are NOT recommended.

80. Any recurrence of symptoms or onset of new symptoms during the therapeutic decompression is to be treated by further recompression to the new depth of relief, the subsequent decompression, after 30 minutes at that depth of relief, must be at the appropriate therapeutic rate, or slower.

81. For divers whose symptoms begin during the decompression from the original dive, ie while still breathing oxy-helium, the treatment is essentially similar to that described already. Recompress, using pure helium, to the depth of complete relief of symptoms, wait 30 minutes at that depth, then decompress in accordance with Table 6.

82. After decompression sickness (whether or not it was severe enough to require recompression) a lay-off period of 5 days at atmospheric pressure is essential in order to prevent recurrence of the manifestation on the subsequent dive. Flying at altitude greater than 1000 feet and mountain climbing are also to be avoided within this period.

TABLE 6

OXY-HELIUM RECOMPRESSION THERAPY

Enter table and after 30 minutes at depth of relief, decompress at rate of ascent given below.

DEPTH (FT) OF RELIEF			RATE OF ASCENT (FT/HOUR) -*1
Greater than 450 ft - *2			15 -
450	-	330'	12
330	-	250	8
250	-	180	6
180	-	70	5
70	-	40	4
40	-	10	3
10	-	to surface - *3	2

*1 - This decompression should be continuous, but discontinuous decompression in increments of 1 or 2 feet are acceptable.

*2 - Experience at depths deeper than 450 ft is very limited.

*3 - If the doors of the chamber are unable to hold the last few feet of pressure an acceptable alternative is to remain at 10 ft for 6 hours and then surface in 1 minute.

ATMOSPHERE CONTROL DURING DECOMPRESSION

pO_2 0.3 atm preferred, but must be kept within the limits 0.2 to 0.6 atm.

pCO_2 maximum 0.005 atm.

For samples analysed at atmospheric pressure see ~~Table 5~~.